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EDITORIAL

Advances in Abiotic Stress Management in Agricultural Crops

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1 Abiotic Stress in Agricultural Crops Progress

Due to climate change, agricultural activity has encountered significant difficulties due to limitations in cultivation, especially in arid and semi-arid regions, such as low rainfall and irregularity, the presence of saline soils, water unsuitable for consumption and irrigation, as well as the limited use of technologies for better utilization of natural resources. The management of crops adapted to abiotic stresses is a viable strategy in the face of climate change. Despite crops' adaptability to soil, temperature, relative humidity, and photoluminosity conditions, abiotic stresses such as drought and salinity are highly damaging to plants [1–3]. Effects such as decreased water and osmotic potential, in addition to specific ionic actions and nutritional and hormonal imbalances in plants, cause disturbances in cell membrane permeability, germination, changes in stomatal conductance, in the photosynthetic process, in the quantum efficiency of photosystem II, gene expression, accumulation of compatible solutes and ions in the apoplast and vacuole, resulting in reduced plant growth and development [4–6]. It is important to emphasize that tolerance to abiotic stress is therefore variable between species and within the same species across developmental phases. In general, it has been identified as a phenomenon specific to a developmental stage, with a genotype potentially being more tolerant at one stage and more sensitive at another [6,7].

In this context, irrigated agriculture becomes essential to guarantee food production, income generation, and regional development. However, water scarcity, driven by irregular rainfall, soil salinization, and limited availability of high-quality irrigation water, compromises the sustainability of production systems. The worsening of climate change has intensified desertification, water and saline stress, and reduced agricultural productivity across different territories [8,9]. Studies that demonstrate strategies for coping with drought and salinity, integrating different areas of knowledge such as the identification of tolerant genotypes, plant physiology, biochemistry, the use of abiotic stress elicitors, soils, irrigation, and plant nutrition, are indispensable.

Agriculture is one of the pillars of human survival and socioeconomic balance. However, its direct dependence on environmental conditions makes it vulnerable to climate change and soil degradation, which have intensified in recent decades. The occurrence of droughts and the salinization of irrigated soils continue to increase, as do extreme temperature fluctuations, posing serious challenges to food production. Understanding how plant growth will respond enables us to develop strategies to mitigate the impacts of climate change in this sector. With this objective in mind, the special edition "Abiotic Stress in Agricultural Crops" was created, bringing together contributions from researchers who strive to understand and develop solutions to abiotic stress. Each published article not only presents scientific data but also offers practical reflections on how to adapt management practices and support agricultural crops in a rapidly changing climate.

2 Key Advances and Contributions

2.1 Elicitors of Salt Stress Tolerance during Germination and Early Growth of Basil (Ocimum basilicum L.) (Silva et al.)

Silva et al. demonstrate plant stress physiology by demonstrating cultivar-dependent responses of basil to salinity during germination. The Limoncino cultivar shows naturally salt-tolerant cultivar that maintains germination performance and biomass accumulation under NaCl stress, whereas Genaro de Menta shows pronounced sensitivity. They show that seed pre-treatments with salicylic acid and ascorbic acid effectively attenuate salt-induced damage by improving germination speed, root growth, and osmotic adjustment through the accumulation of compatible solutes. Their findings provide a practical, low-cost strategy to enhance basil establishment and productivity in saline agricultural environments [10].

2.2 The Combination of Appropriate Drip Irrigation and Straw Mulching Increased the Yield of Maize (Xu et al.)

Xu et al. associated drip irrigation with straw mulch return enhances maize physiological performance, nutrient transport, carbon–nitrogen metabolism, and yield formation under water-limited conditions. They show that moderate irrigation levels combined with straw return improved root bleeding sap composition, delayed leaf senescence through hormonal regulation, and stimulated key enzymes associated with photosynthesis and nitrogen assimilation. The findings show that straw mulching maximizes water-use efficiency and mitigates drought impacts, providing a practical and sustainable strategy for maize production in semi-arid, water-scarce agricultural regions [11].

2.3 Tolerance of Sweet Sorghum (Sorghum bicolor) to Water Deficit and Irrigation Water Salinity: Water Relations and Production (Silva et al.)

Silva et al. investigates the tolerance of sweet sorghum cultivar BRS 506 to different levels of water salinity and water scarcity in semi-arid regions. The study is critical because, in addition to being a source of energy and food, sorghum has excellent potential as a bioenergy crop. The results demonstrate that sorghum has the potential to adjust physiologically, maintaining water balance and acceptable productivity even under less favorable conditions. This finding reaffirms that, with proper management, it is possible to use lower-quality water—more saline—in arid regions, representing another practical step towards sustainable agriculture [12].

2.4 Evaluation of Seaweeds as Stimulators to Alleviate Salinity-Induced Stress on Some Agronomic Traits of Different Peanut (Arachis hypogaea L.) Cultivars (Sahin)

Sahin focuses on a potential research area: the use of natural biostimulants. The author tested seaweed extracts as an alternative to reduce salinity's impact on four peanut cultivars. The study, conducted in a controlled environment, demonstrated that the extracts enhanced seedling growth and emergence under saline stress. The study reveals the potential of bio-inputs as ecological and low-cost tools, capable of improving plant performance under adverse conditions—a topic of growing relevance, given the increasing demand for less polluting and non-synthetic chemical agricultural practices [13].

2.5 Effects of Drought Stress on the Physiological Characteristics of Flue-Cured Tobacco during the Vigorous Growing Period (Wei et al.)

Wei et al. examines how drought affects air-cured tobacco (variety K326) at different soil moisture levels. The research evaluates parameters such as photosynthetic pigments, chlorophyll fluorescence, and antioxidant enzyme activity. The results show a reduction in chlorophyll concentrations, associated with alterations in metabolic pathways involved in energy dissipation. The study provides information on how tobacco physiologically responds to drought. In addition to understanding the plant's defense mechanisms *in vivo*, this will help develop better crop management practices and use more tolerant varieties in plant breeding programs [14].

2.6 Enhancing Salt Stress Tolerance in Portulaca oleracea L. Using Ascophyllum nodosum Biostimulant (Alhawsa et al.)

Alhawsa et al. addresses salt stress tolerance in *Portulaca oleracea* L. using *Ascophyllum nodosum* biostimulant. The use of the biostimulant Ascophyllum nodosum reinforces the role of marine biostimulants in the cultivation of *Portulaca oleracea* L., a vegetable with high nutritional value. The experiment demonstrated that the brown algal extract Ascophyllum nodosum significantly improved plant growth under moderate salinity. This result confirms that natural solutions can act as "physiological shields", helping plants to tolerate saline conditions without compromising growth. In addition, the study offers promising avenues for growing vegetables in salinized soils, a phenomenon increasingly observed in irrigated areas worldwide [15].

2.7 Effect of Proline Pretreatment on the Water Stress Response in "Siete Caldos" Pepper Plants (Trejo-Paniagua et al.)

Trejo-Paniagua et al. presents an innovative adaptation strategy: pretreatment with proline. The research demonstrated that immersing the roots of 'Siete Caldos' pepper seedlings in proline solutions before exposure to drought significantly reduced the physiological damage caused by a lack of water. This technique, called "osmotic conditioning," is simple and effective and can be adopted on a large scale, especially in vegetable gardens and small farms that face drought or limited irrigation. The study highlights that plant resilience can be induced—that is, built even before stress occurs—a powerful idea for modern agricultural management [16].

2.8 Assessing Stress Tolerance of SUBI and DRO1 Introgression Lines under Flooding and Drought Conditions at Different Growth Stages (Soe et al.)

Soe et al. addresses the dual challenge of tolerance to both drought and flooding, which are becoming increasingly common climatic extremes. The researchers evaluated rice lines containing the SUB1A (submergence resistance) and DRO1 (deep root growth) genes, both introduced into the IR64 variety. The study revealed that specific genetic combinations can provide simultaneous tolerance to different types of stress. This is an important discovery, as it opens new possibilities for developing cultivars that can cope with unpredictable climate variability, which is increasingly urgent for global food security [17].

3 Future Directions and Challenges

Overall, the articles in this special issue represent a mosaic of complementary approaches, ranging from research on physiological and molecular defense mechanisms in plants to the use of sustainable technologies, such as biostimulants and osmotic conditioners. This diversity reflects the essence of modern agriculture, which must combine science, innovation, and ecologically responsible practices to produce more efficiently and sustainably. More than just gathering scientific results, "Abiotic Stress in Agricultural Crops" conveys a clear message: adaptation is possible. Each investigation presented offers a new perspective on agricultural management, balancing productivity and the preservation of natural resources. In a world of increasingly scarce water resources and frequently degraded soils, the search for resilient plants and intelligent management practices is the only way to guarantee the future of human food. Thus, this edition not only expands scientific knowledge but also inspires a more conscious and sustainable agriculture capable of facing the environmental challenges already upon us.

4 List of Contributions

1. da Silva EA, Costa Neto JB, Barreto SN, de Souza Alencar MH, de Mesquita Arruda MV, da Rocha DF, et al. Elicitors of salt stress tolerance during germination and early growth of basil (*Ocimum basilicum* L.). Phyton-Int J Exp Bot. 2026;95(4):67203. doi:10.32604/phyton.2026.077713.
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4. Sahin NK. Evaluation of seaweeds as stimulators to alleviate salinity-induced stress on some agronomic traits of different peanut (*Arachis hypogaea* L.) cultivars. Phyton-Int J Exp Bot. 2025;94(8):2399–421. doi:10.32604/phyton.2025.067880.
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8. Soe I, Odama E, Tamu A, Wani ALL, Ookawa T, Ismail AM, et al. Assessing stress tolerance of *SUB1* and *DRO1* introgression lines under flooding and drought conditions at different growth stages. Phyton-Int J Exp Bot. 2025;94(2):303–16. doi:10.32604/phyton.2025.060016.

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